

# Claims

- [c1] 1. A method for controlling battery discharge power limits for an electric battery in a vehicle powertrain, the electric battery being a source of power for an electric motor, the electric battery having a calibrated voltage set point that defines a limit for battery discharge voltage, the method comprising:
- computing an estimated electric battery power limit during battery discharge;
  - measuring commanded electric battery power;
  - determining whether commanded electric battery power exceeds an estimated battery power limit;
  - measuring actual battery voltage; and
  - computing a modified battery power limit if the actual battery voltage exceeds the battery discharge voltage limit.
- [c2] 2. A method for controlling battery charge power limits for an electric battery in a vehicle powertrain, the electric battery being a source of power for an electric motor, the electric battery having a calibrated voltage set point that defines a limit for battery charge voltage, the method comprising:

computing an estimated battery power limit during battery charging;  
measuring commanded electric battery power;  
determining whether commanded electric battery power exceeds an estimated battery power limit;  
measuring actual battery voltage; and  
computing a modified battery power limit if the actual battery voltage exceeds the battery voltage charge limit.

- [c3] 3. A method for controlling battery discharge power limits for an electric battery in a vehicle powertrain, the battery being a source of power for an electric motor, the battery having a calibrated voltage set point that defines a limit for battery discharge voltage, the method comprising:
- measuring actual battery current;
  - measuring an error between the battery discharge voltage set point and the actual battery voltage using the actual voltage in a voltage closed loop feedback control;
  - determining a battery discharge power limit;
  - computing a voltage proportional term and a voltage integral term based on the error; and
  - multiplying the sum of the proportional term and the integral term by the actual battery current to obtain a power limit modification thereby preventing a battery discharge voltage in excess of the battery discharge set

point.

- [c4] 4. A method for controlling battery charge power limits for an electric battery in a vehicle powertrain having an electric battery as a source of power for an electric motor, the battery being a source of power for an electric motor, the battery having a calibrated voltage set point that defines a limit for battery charge voltage, the method comprising:
- measuring an error between the battery charge voltage set point and actual battery voltage using actual voltage in a voltage closed loop feedback control;
  - determining a battery charge power limit;
  - computing a voltage proportional term and a voltage integral term based on the error;
  - measuring actual battery current; and
  - multiplying the sum of the proportional term and the integral term by the actual battery current to obtain a power limit modification thereby preventing a battery charge voltage in excess of the battery charge set point.
- [c5] 5. The method set forth in claim 3 wherein the step of measuring actual battery current includes filtering the battery current with a low pass filter with a filter time constant that can be varied depending on noise level.
- [c6] 6. The method set forth in claim 4 wherein the step of

measuring actual battery current includes filtering the battery current with a low pass filter with a filter time constant that can be varied depending on noise level.

- [c7] 7. A control system for a battery power limit in a vehicle powertrain in which a battery is a vehicle power source comprising:
- a battery controller;
  - a motor driveably connected to a power output, the motor being electrically coupled to the battery controller;
  - a vehicle system controller for receiving driver commands and delivering control commands to the motor;
  - a proportional–integral controller with a battery voltage set point input, a battery voltage input and a battery current input;
  - a comparator communicating with the vehicle system controller and the proportional–integral controller whereby battery power limits are compared to power limits established by the battery controller;
  - the vehicle system controller being configured to develop battery power commands in response to driver commands; and
  - a power limit closed loop control communicating with the proportional–integral controller and with the battery whereby a power limit for the battery is modified to maintain battery voltage at a value that does not exceed

the battery voltage set point.

- [c8] 8. The control system set forth in claim 7 wherein the battery voltage set point is a battery discharge voltage set point.
- [c9] 9. The control system set forth in claim 7 wherein the battery voltage set point is a battery charge voltage set point.
- [c10] 10. The method set forth in claim 3 wherein the measured actual battery current is clipped during discharge to values greater than or equal to zero.
- [c11] 11. The method set forth in claim 10 wherein the error is clipped to positive values whereby the proportional term modifies the battery discharge power limit only if the actual voltage is below the discharge voltage set point.
- [c12] 12. The method set forth in claim 11 wherein the clipped error signal is multiplied by a proportional gain to compute the proportional term.
- [c13] 13. The method set forth in claim 3 wherein the integral term is prevented from increasing if the power limit modification is greater than the limit for battery discharge voltage.
- [c14] 14. The method set forth in claim 13 wherein the inte-

gral term is reset to zero if the integral term becomes negative.

- [c15] 15. The method set forth in claim 3 wherein the measured actual battery current is clipped during charging to values less than or equal to zero and absolute values are used.
- [c16] 16. The method set forth in claim 15 wherein the error is clipped to negative values whereby the proportional term modifies the battery charge power limit only if the actual voltage is below the charge voltage set point.
- [c17] 17. The method set forth in claim 16 wherein the clipped error signal is multiplied by a proportional gain to compute the proportional term.
- [c18] 18. The method set forth in claim 3 wherein the integral term is prevented from increasing if the power limit modification is less than the limit for battery charge voltage.
- [c19] 19. The method set forth in claim 18 wherein the integral term is reset to zero if the integral term becomes positive during battery charging.